$\mu_B = 9.27 \times 10^{-24} Am^2$

$\epsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$

$m_e = 9.1 \times 10^{-31} kg$

$e = 1.6 \times 10^{-19} C$

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4104 **H**

Unique Paper Code : 2222012402

Name of the Paper : Solid State Physics

Name of the Course : **B.Sc. (Hons.) Physics (NEP)**

Semester : IV

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** question in all.
3. Each question carry **18** marks.
4. Question No. **1** is compulsory and each part carries 3 marks.
5. Use of non-programmable scientific calculators is allowed.

1. (a) Why lower branch of the dispersion curve for a linear diatomic crystal is called acoustic branch, even though the frequency associated with it is in IR (Infra-red) region?

(b) Calculate the Hall voltage in a sample when the magnetic field of 1 Tesla is applied perpendicular to the current direction. The injected current is 300 mA and thickness of the sample is 0.4 mm. The charge carrier concentration in the sample is 10^{21} m^{-3}.

(c) In CsCl, the Cs atoms are located at the comers of a cube and Cl at the body centre. What is the Bravais lattice for this material? Draw the Bravias lattice and identify the basis/motiff.

(d) X-rays of wavelength 0.3 Å are allowed to fall on a crystal whose interplanar spacing for a particular set of planes is 3 Å. Determine the smallest angle at which the X-rays are diffracted by the crystal.

6. (a) Describe the classical theory of diamagnetism. Explain the concept of Larmour precession. Derive the expression of the Larmor frequency. (9)

(b) What are ferromagnetic domains? Using the concept of domains, explain the B-H hysteresis curve. What does the area under the curve signify? (6)

(c) A paramagnetic material has 10^{28}atoms/m^3. Its susceptibility at 350K is 2.8×10^{-4}. Calculate the susceptibility at 300K. (3)

Values of Constants

$k_B = 1.38 \times 10^{-23}$ JK^{-1}

$N_A = 6.02 \times 10^{23}$ mol^{-1}

$h = 6.63 \times 10^{-34}$ Js

$\mu_0 = 4\pi \times 10^{-7}$ Hm^{-1}

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(c) Determine the critical field required to destroy superconductivity at 5K in Pb whose Tc is 7.19 K and $H_c(0) = 0.0803$ T. (4)

5. (a) What is local electric field of an atom? Deduce the Lorentz relation for E_{local} inside a dielectric. (9)

(b) Give a schematic sketch of the variation of the total polarizability of a dielectric material as a function of frequency, explaining the physical origin of the various contributions and the relative frequency ranges. (6)

(c) A potential 12V is applied across the plates of a parallel plate capacimtor having an area $6.45 \times 10^{-4}m^{-2}$ and a plate separation of 2×10^{-3}m. If a material having a dielectric constant 5.0 is positioned within the region between the plates, compute the polarization. (3)

(e) Describe the characteristic properties of ferroelectric crystals and which symmetry element is missing in these types of crystals.

(f) Explain the concept of the orbital magnetic dipole moment of an electron in an atom and derive an expression for it in terms of angular momentum of the electron.

2. (a) If 'a' is the lattice constant of a cubic unit cell, draw the planes which makes an intercept, in terms of 'a, along the coordinate axis as

(i) 1/2, 1/3, ∞

(ii) -1/2, ∞, ∞

(iii) What does <100> and [100] signifies?

(5)

(b) Silver crystallizes in fee structure and every silver atom gives one electron to the crystal. If the interplanar separation is 2.87 Å, determine density and electron concentration in it. Atomic weight of silver is 107.68 amu. (5)

(c) Draw a square reciprocal lattice and explain the Ewald's construction and its significance? Derive vector form of the Bragg's law from the construction and explain its physical significance. (8)

3. (a) State Bloch's theorem. What is the idea behind Writing the electron wave-function as Bloch function? What are the assumptions of Kronig-Penney model? Show that for one dimensional crystal having finite length L with N number of primitive unit cells of lattice constant 'a', the total number of allowed k-values in the first Brillouin zone is equal to the number of unit cells. (9)

(b) Discuss Meissner effect and distinguish between Type I and Type II Superconductors. (6)

(c) Calculate the effective mass of an electron near the top of the valence band in potassium crystal. The E-K relationship for the crystal is $E(k) = 2 - 8\cos\left(\frac{ka}{2}\right)$ and lattice constant is 5.328 Å. (3)

4. (a) Derive an expression for the dispersion relation of a linear monoatomic crystal. The mass of the atoms is 'm' and force constant between them is 'c'. Sketch the dispersion curve within the first Brillouin zone and explain the various characteristics of the crystal dynamics. (9)

(b) Estimate the Debye temperature of Gold if its atomic weight is 197 amu, density is 1.9×10^4 Kg/m^3 and the sound velocity in it is 2100 ms^{-1}. (5)